The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed Stephen Hordley

Dated 26 November 2003

An Executive Agency of the Department of Trade and Industry

THIS PAGE BLANK (USPTO)

**Patents Form 1/77**

Pat[illegible]s Act 1977
(R[illegible]3)

The Patent Office

# 1/77

04DEC02 E768250-1 D01914
P01/7700 0.00-0228203.6

THE PATENT OFFICE
- 3 DEC 2002
RECEIVED BY HAND

## Request for grant of a patent

*(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)*

The Patent Office

Cardiff Road
Newport
South Wales
NP9 1RH

| | |
|---|---|
| 1. Your reference | MJN/67852/000 |
| 2. Patent application number *(The Patent Office will fill in this part)* | 0228203.6 — 03 DEC 2002 |
| 3. Full name, address and postcode of the or of each applicant *(underline all surnames)* | ABB Offshore Systems Limited<br>2 High Street<br>Nailsea<br>Bristol BS48 1BS |
| Patents ADP number *(if you know it)* | 07692221001 |
| If the applicant is a corporate body, give the country/state of its incorporation | United Kingdom (GB) |
| 4. Title of the invention | A SYSTEM FOR USE IN CONTROLLING A HYDROCARBON PRODUCTION WELL |
| 5. Name of your agent *(if you have one)*<br>"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* | PAGE HARGRAVE<br>Southgate, Whitefriars<br>Lewins Mead<br>BRISTOL BS1 2NT |
| Patents ADP number *(if you know it)* | 05996483001 |

| | Country | Priority application number *(if you know it)* | Date of filing *(day / month / year)* |
|---|---|---|---|
| 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number. | | | |

| | Number of earlier application | Date of filing *(day / month / year)* |
|---|---|---|
| 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application | | |

| | |
|---|---|
| 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*<br>*a) any applicant named in part 3 is not an inventor, or*<br>*b) there is an inventor who is not named as an applicant, or*<br>*c) any named applicant is a corporate body.*<br>*See note (d))* | Yes |

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

| | |
|---|---|
| Continuation sheets of this form | - |
| Description | 6 |
| Claim *(s)* | 2 |
| Abstract | 1 |
| Drawing *(s)* | ~~4~~ 4+4 |

10. If you are also filing any of the following, state how many against each item.

| | |
|---|---|
| Priority documents | - |
| Translations of priority documents | - |
| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | Two |
| Request for preliminary examination and search *(Patents Form 9/77)* | One |
| Request for substantive examination *(Patents Form 10/77)* | - |
| Any other documents *(please specify)* | - |

11. I/We request the grant of a patent on the basis of this application.

Signature PAGE HARGRAVE Date 02/12/02

12. Name and daytime telephone number of person to contact in the United Kingdom

**Mr M J Newstead (0117) 927 6634**

**Warning**

*After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.*

**Notes**

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

**Patents Form 7/77**

Patents Act 1977
(Rule 15)

The Patent Office

# 7/77

THE PATENT OFFICE
- 3 DEC 2002
RECEIVED BY HAND

**The Patent Office**

Cardiff Road
Newport
South Wales
NP9 1RH

## Statement of inventorship and of right to grant of a patent

| | | |
|---|---|---|
| 1. | Your reference | MJN/67852/000 |
| 2. | Patent application number *(if you know it)* | |
| 3. | Full name of the or of each applicant | ABB Offshore Systems Limited |
| 4. | Title of the invention | A SYSTEM FOR USE IN CONTROLLING A HYDROCARBON PRODUCTION WELL |
| 5. | State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent | By virtue of a contract of employment between the applicant and the inventor. |
| 6. | How many, if any, additional Patents Forms 7/77 are attached to this form? *(see note (c))* | - |
| 7. | | I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/are the inventor*(s)* of the invention which the above patent application relates to.<br>Signature Date 02/12/02<br>PAGE HARGRAVE |
| 8. | Name and daytime telephone number of person to contact in the United Kingdom | Mr M J Newstead (0117) 927 6634 |

**Notes**

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there are more than three inventors, please write the names and addresses of the other inventors on the back of another Patents Form 7/77 and attach it to this form.*

d) *When an application does not declare any priority, or declares priority from an earlier UK application, you must provide enough copies of this form so that the Patent Office can send one to each inventor who is not an applicant.*

e) *Once you have filled in the form you must remember to sign and date it.*

Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

Christopher David <u>Baggs</u>
Annesley House
21 Southside
Weston-Super-Mare
Somerset BS23 2QU

07883218001

Patents ADP number *(if you know it)*:

Patents ADP number *(if you know it)*:

Patents ADP number *(if you know it)*:

**Reminder**

**Have you signed the form?**

# A SYSTEM FOR USE IN CONTROLLING A HYDROCARBON PRODUCTION WELL

The present invention relates to a system for use in controlling a hydrocarbon production well.

In the subsea fluid extraction industry, communication is required between a control centre and well heads located on the seabed. Traditionally, the control centre is located on a platform or vessel in relatively close proximity to the well complex. In some cases, the control centre is located on land, where the distance from the control centre to the well heads can be much greater and could be typically 200km. High capacity communication systems, typically involving optical fibres, allow the possibility of much higher data rates between the subsea and surface facilities, which further enables methods of connecting subsea data sources (e.g. sensors), particularly those generating large quantities of data such as microseismic sensors and TV cameras.

A conventional approach is to use a standard subsea bus at the well head ends of a data transmission system to connect such various subsea data sources. This means that any other party providing equipment to the system has to interface with the bus and conform to its protocol, data rates and bus standards. Since different manufacturers have standard equipment with interfaces to a multiplicity of protocols and data rates, substantial costs are involved in adapting these interfaces to suit the standard bus. Furthermore, since this data is time multiplexed on the bus, the data rates are also somewhat limited such that some desirable, high bandwidth, data transmissions, such as digital video signals, cannot be economically transmitted.

Fig. 1 shows a conventional system for the communication of data between subsea well trees and a surface facility. Mounted on each of a number of subsea well trees (not shown) is a subsea electronics module (SEM) 1 including a SEM processor 2, which handles at a port 3 data from conventional tree sensors such as pressure and temperature and at a port 4 data for control of devices such as valves and fluid control chokes, there being a port 5 for a standard interface for data from other subsea data sources. The SEM

processor 2 communicates bi-directionally with a surface facility computer system 6 (on shore or on a platform for example) via a modem 7 housed in the SEM 1, a communication link 8 and a modem 9 housed in a surface modem unit (SMU) 10 at the surface facility. The communication link 8 enables communication with the SEMs of other well trees and at some or all of the well trees there is system duplication to improve system availability - thus in Fig. 1 there are shown two SEMs (SEM A1 and SEM B1) for a particular well tree; SEM A2 and SEM B2 representing duplicate SEMs for another tree.

When the surface computer 6 is located at a considerable distance, such as, typically, 200km from the well complex, a fibre optic link is used as link 8 to transmit data between the or each SEM at a well tree to the surface computer 6. Nevertheless, the data from other sources at port 5 needs to be adapted to the protocol, data rates and other standards used for the communication of control information and sensor information.

According to the present invention, there is provided a system for use in controlling a hydrocarbon production well, comprising:

a) computing means at a control location remote from a well tree of the well;

b) well tree means comprising:

   i) processing means for applying control signals to and receiving signals from devices of the well tree; and

   ii) means for receiving further signals associated with the operation of the well;

and

c) a bi-directional communication link between said computing means and said well tree means, wherein the well tree means further comprises:

   iii) a communications router coupled with said processing means and said receiving means, for multiplexing said signals from devices at the well head and said further signals on to said bi-directional link.

Said bi-directional link could comprise a fibre optics link.

There could be a plurality of such well tree means at respective well trees, there being distribution means between said bi-directional link and the well tree means for distributing control signals to said well tree means and receiving multiplexed signals from said well tree means.

Said signals from devices at the well head and said further signals could have different protocols and different data speeds.

Said further signals could include video signals.

The present invention also comprises a combination of a system according to the invention providing a first communication channel, and a further such system, providing a second communication channel for use if the first channel fails.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagram of a known form of system for use in controlling a hydrocarbon production well;

Fig. 2 is a diagram of an example of a system according to the present invention;

Fig. 3 is a diagram of another example of the present invention; and

Fig. 4 is a diagram showing part of an alternative to what is shown in Fig. 3.

Fig. 2 (in which items which correspond with those in Fig. 1 have the same reference numerals as in Fig. 1) illustrates a system according to an example of the invention, showing linking from a surface computer 6 to a well tree. The surface computer 6 at the control centre (on shore or on a platform for example) sends and receives data to and

from a surface modem unit (SMU) 10 which houses a modem 9. This modem 9 transmits and receives data via a communication link 8. The other end of the communication link 8 connects to the well head tree which carries a subsea electronics module (SEM) 11 which houses a modem 7 which is a similar device to the modem 9 and performs the opposite function. The modem 7 has an electrical output/input, which is connected to a communications processor 12 which functions as a communications router (or intelligent multiplexer), also housed in the SEM 11. The communications router 12, has a multiplicity of inputs/outputs, there being an interface with a conventional SEM processor 2 (having sensor, control and standard interface ports 3, 4 and 5) and also interfaces 13 which interface with other 'private' standard interfaces known as virtual links. The interfaces are effectively 'star connected' rather than the conventional 'highway connected' and virtually any protocol and data rate can be handled, limited only by the router 12, speed and the final limitation of the bandwidth of the communication link 8 and its modems 7 and 9. Typically, the link 8 could be about 200km in length, data being transmitted via it at typically 10Mbits/sec. The software in the router 12 is flexible and handles, by multiplexing, the data and protocol of the 'private' interfaces, as required for the system configuration, to permit high speed communication to and from the modem 7, thereby providing virtual links between the surface and subsea equipment. The SEM processor 2 handles the conventional control of subsea devices, such as valves and chokes, to control the fluid extraction process. It also handles local logging and processing of data from the tree sensors, its main functions being to acquire data from the sensors and assemble it into a format that can be transmitted to the surface computer and to issue control signals to valves and fluid control chokes for example.

Typical of the above-mentioned private, standard interfaces are the intelligent well system interface, (IWS) (an Ethernet interface), and others as shown in Fig. 2 which are well known in the industry, as well as interfaces to devices such as level sensors, microseismic sensors and fluid quality sensors. Due to the fact that the system configuration allows high bandwidth utilisation of the communication link 8, typically a fibre optic link, it is possible to transmit compressed video. This allows the fitting of cameras to the subsea well head, to permit visual inspection of the tree without the need

for expensive diving operations or the use of a remote operation vehicle (ROV). This will have major benefits to the well operator who, in the past, has had to rely on sensor information to prompt the deployment of divers or a ROV to effect a visual inspection, but can now have a continuous visual inspection facility.

Fig. 3 (in which items which correspond with those in Fig. 2 have the same reference numerals as in Fig. 2) shows a typical full system implementation to handle communication between a control centre and a subsea well complex, and providing high availability through dual duplex redundancy. The figure shows a high end application with a large amount of redundancy and long distance offsets with a subsea central distribution system arrangement that sits between a surface computer and well head control modules.

Two separate communication channels are provided, A and B, to provide 100% redundancy. Describing channel A, a surface computer 6 at the control centre (on shore or on a platform for example) feeds and receives data to and from an SMU 14 which houses two bi-directional optical modems 15 and 16.

The optical modems 15 and 16 interface with respective ones of a pair of optical fibres 17 and 18, which terminate near to a well head complex at a communication electronics module (CEM) 19 typically located on the seabed. Typically, the communication link provided by the optical fibres could be about 200km, data being transmitted via them at typically 10Mbits/sec. The CEM 19 enables interfacing of many wells in the locality with the optical fibres 17 and 18. The use of two optical fibres provides further redundancy and thus greater communications reliability. The CEM 19 houses another two bi-directional optical modems 20 and 21 coupled with respective ones of fibres 17 and 18 and which output electrical signals to a communications router 22. The communications router 22 interfaces with electrical modems, of which three, 23, 24 and 25 are shown, by way of example, each of which interfaces with a modem of a SEM at a well tree. Thus, for example, the modem 23 interfaces with a modem 7 of a SEM 1 via a communication link 26 and with the modems at other trees within the group via a communication link 27 and modems 24 and 25 interface with modems at other groups

of trees via communication links 28 and 29.

Fig. 3 also shows a duplicated identical channel B for use instead of channel A for further reliability. In the event of failure of both channels, rudimentary communication is provided by a link 30 from the computer 6 of each channel, a low speed communications modem (LSCM) 31, a back-up communication link 32 (typically operating at 1.2 kbits/sec) and a link 33 for each channel, each link being coupled by a LSCM 34 to the communications router 22 of the respective channel.

It should be noted that each of modems 23, 24, 25, etc. and each of the corresponding modems at the well tree SEM's, may, alternatively, be of the form that communicates via the electrical power supply to the tree, i.e. a comms-on-power (COP) type of modem.

Fig. 4 shows part of an alternative to the system of Fig. 3, items which correspond with items in Fig. 3 having the same reference numerals as in Fig. 3. Instead of a single back-up communication link, each channel has its own back-up communication link 35 (typically operating at 1.2kbits/sec), being a link which provides subsea power from a 3-phase, 3kv supply and each channel having a respective LSCM 36 instead of there being a single LSCM 31 as in Fig. 3. In Fig. 4, modems 23, 24 and 25 are COP modems.

## CLAIMS

1. A system for use in controlling a hydrocarbon production well, comprising:
   a) computing means at a control location remote from a well tree of the well;
   b) well tree means comprising:
      i) processing means for applying control signals to and receiving signals from devices of the well tree; and
      ii) means for receiving further signals associated with the operation of the well;

   and

   c) a bi-directional communication link between said computing means and said well tree means, wherein the well tree means further comprises:
      iii) a communications router coupled with said processing means and said receiving means, for multiplexing said signals from devices at the well head and said further signals on to said bi-directional link.

2. A system according to claim 1, wherein said bi-directional link comprises a fibre optics link.

3. A system according to claim 1 or 2, wherein there is a plurality of such well tree means at respective well trees, there being distribution means between said bi-directional link and the well tree means for distributing control signals to said well tree means and receiving multiplexed signals from said well tree means.

4. A system according to any preceding claim, wherein said signals from devices at the well head and said further signals have different protocols and different data speeds.

5. A system according to any preceding claim, wherein said further signals include video signals.

6. A combination of a system according to any preceding claim, providing a first communication channel, and a further such system, providing a second communication channel for use if the first channel fails.

7. A system according to any preceding claim, wherein the or each system has a respective back-up communication arrangement between its computing means and the or each well tree means for use if the system fails.

8. A system according to claim 6, including a back-up communication arrangement between the computing means of each channel and the or each well tree means for use if each of the channels fails.

## ABSTRACT

A system for use in controlling a hydrocarbon production well, comprises: computing means (6) at a control location remote from a well tree of the well; well tree means (11, 3, 4, 5, 13) comprising: processing means (2) for applying control signals to and receiving signals from devices of the well tree; and means (13) for receiving further signals associated with the operation of the well; and a bi-directional communication link (8) between the computing means and the well tree means. The well tree means further comprises a communications router (12) coupled with the processing means and said receiving means, for multiplexing the signals from devices at the well head and the further signals on to the bi-directional link.

(Fig. 2)

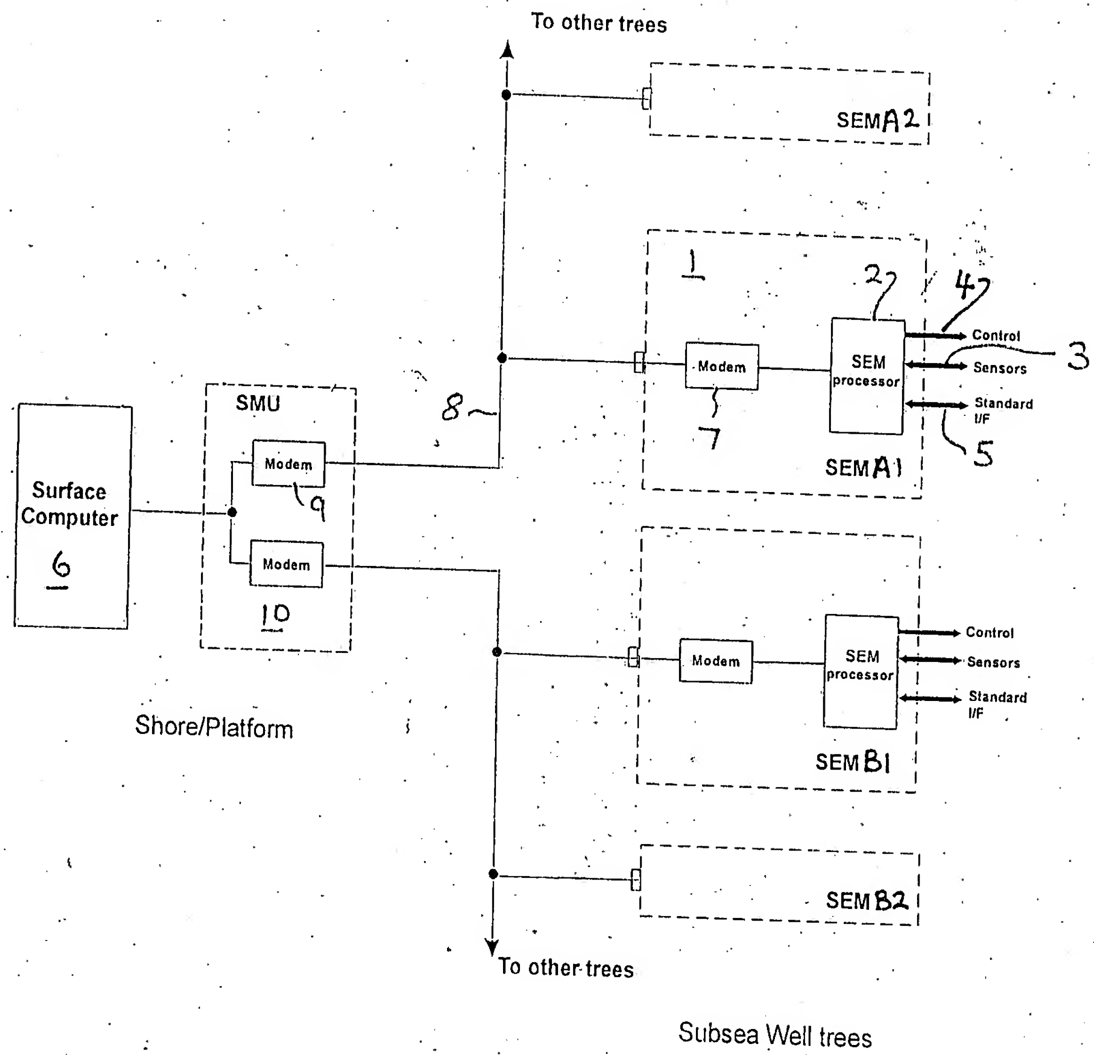
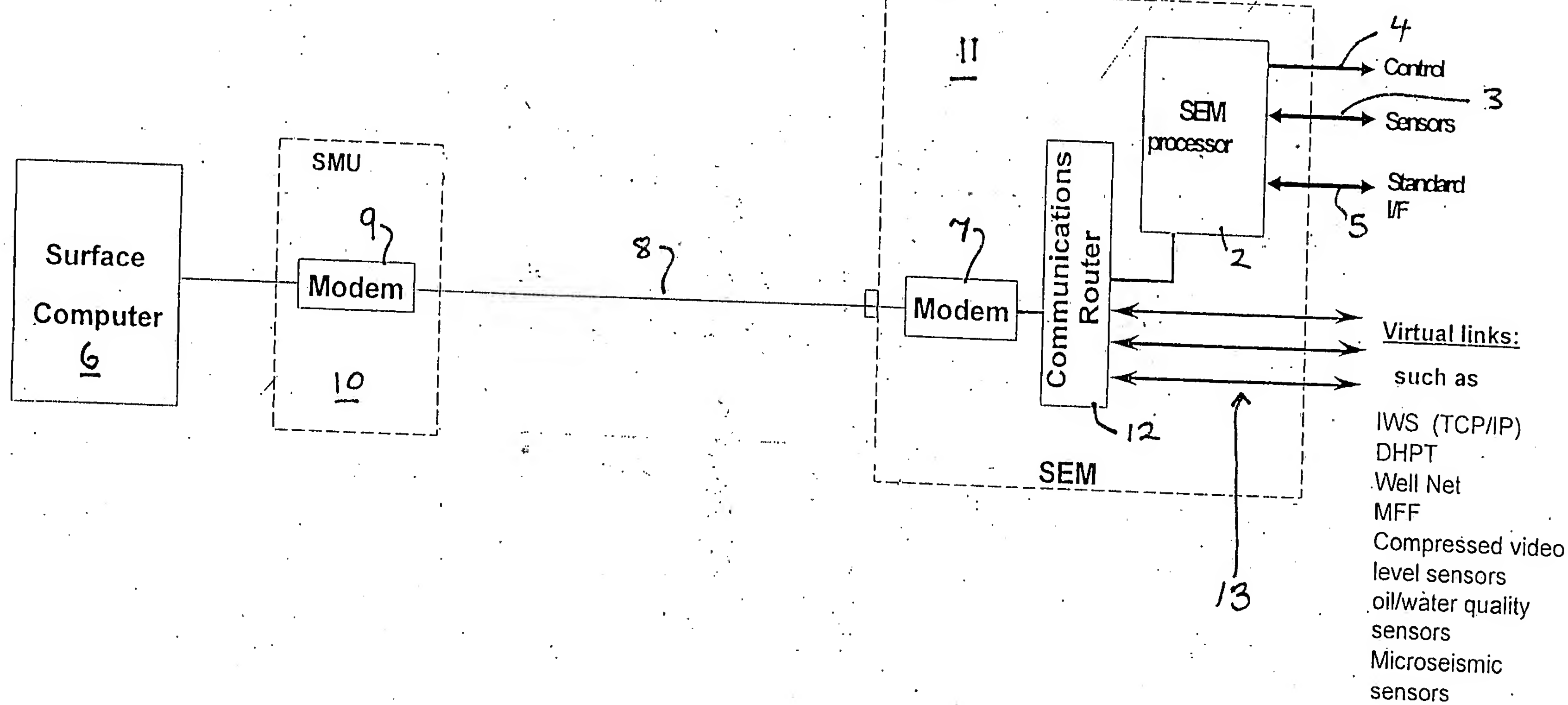

To other trees
SEM A2
1
2
4
Control
3
Sensors
Standard I/F
5
Modem
7
SEM processor
SEM A1
SMU
8
Modem
9
Modem
10
Surface Computer
6
Shore/Platform
Modem
SEM processor
Control
Sensors
Standard I/F
SEM B1
SEM B2
To other trees
Subsea Well trees

Fig.1



Surface
Computer
6
SMU
9
Modem
10
8
11
7
Modem
Communications Router
12
SEM
SEM processor
2
4
Control
3
Sensors
Standard I/F
5
Virtual links:
such as
IWS (TCP/IP)
DHPT
Well Net
MFF
Compressed video
level sensors
oil/water quality sensors
Microseismic sensors
13


Fig.2

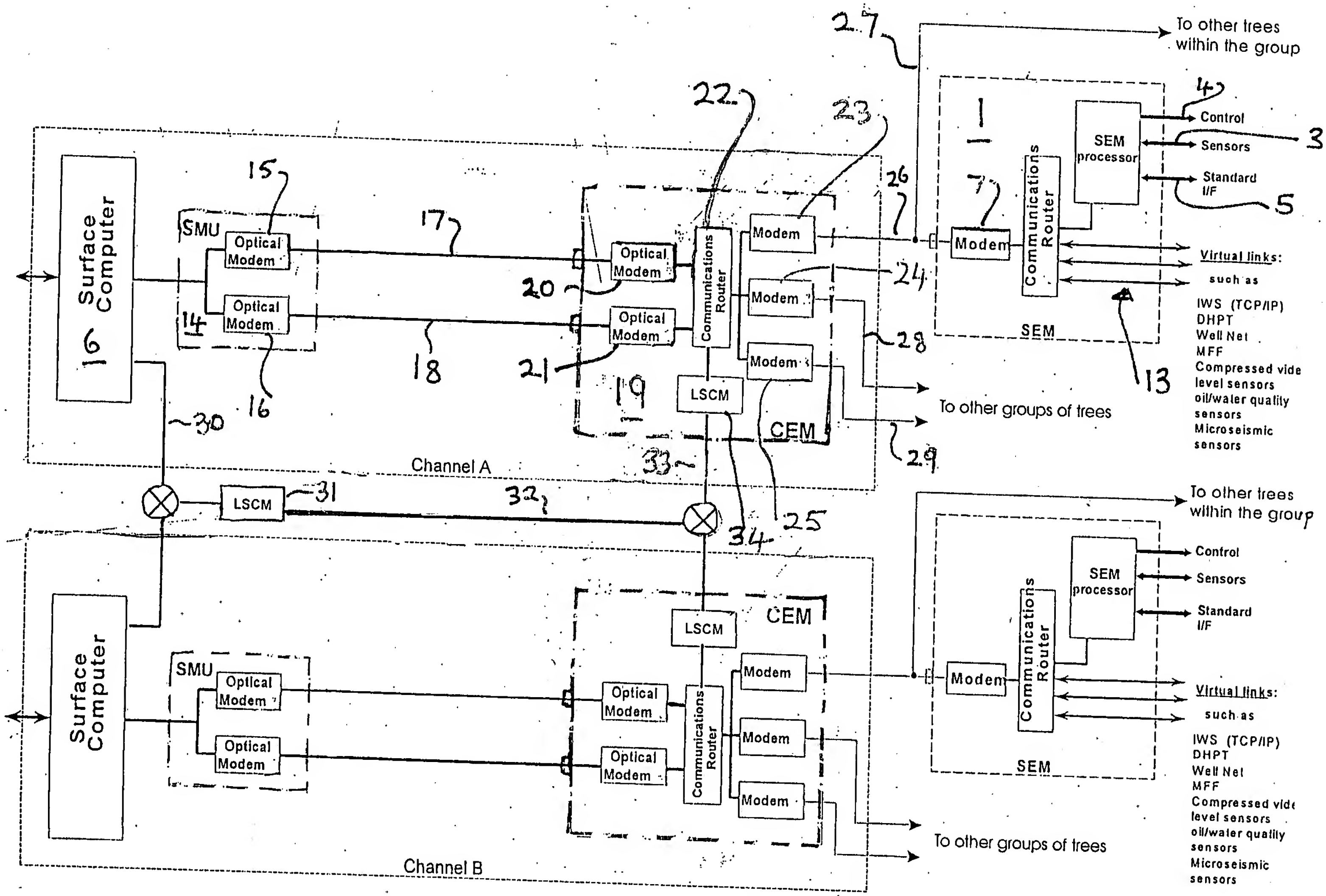

To other trees within the group
Control
Sensors
Standard I/F
SEM processor
Communications Router
Modem
SEM
Virtual links:
such as
IWS (TCP/IP)
DHPT
Well Net
MFF
Compressed vide
level sensors
oil/water quality
sensors
Microseismic
sensors
To other groups of trees
Surface Computer
SMU
Optical Modem
Optical Modem
Communications Router
Modem
Modem
Modem
LSCM
CEM
Channel A
LSCM
Channel B
1
3
4
5
6
7
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

Fig.3

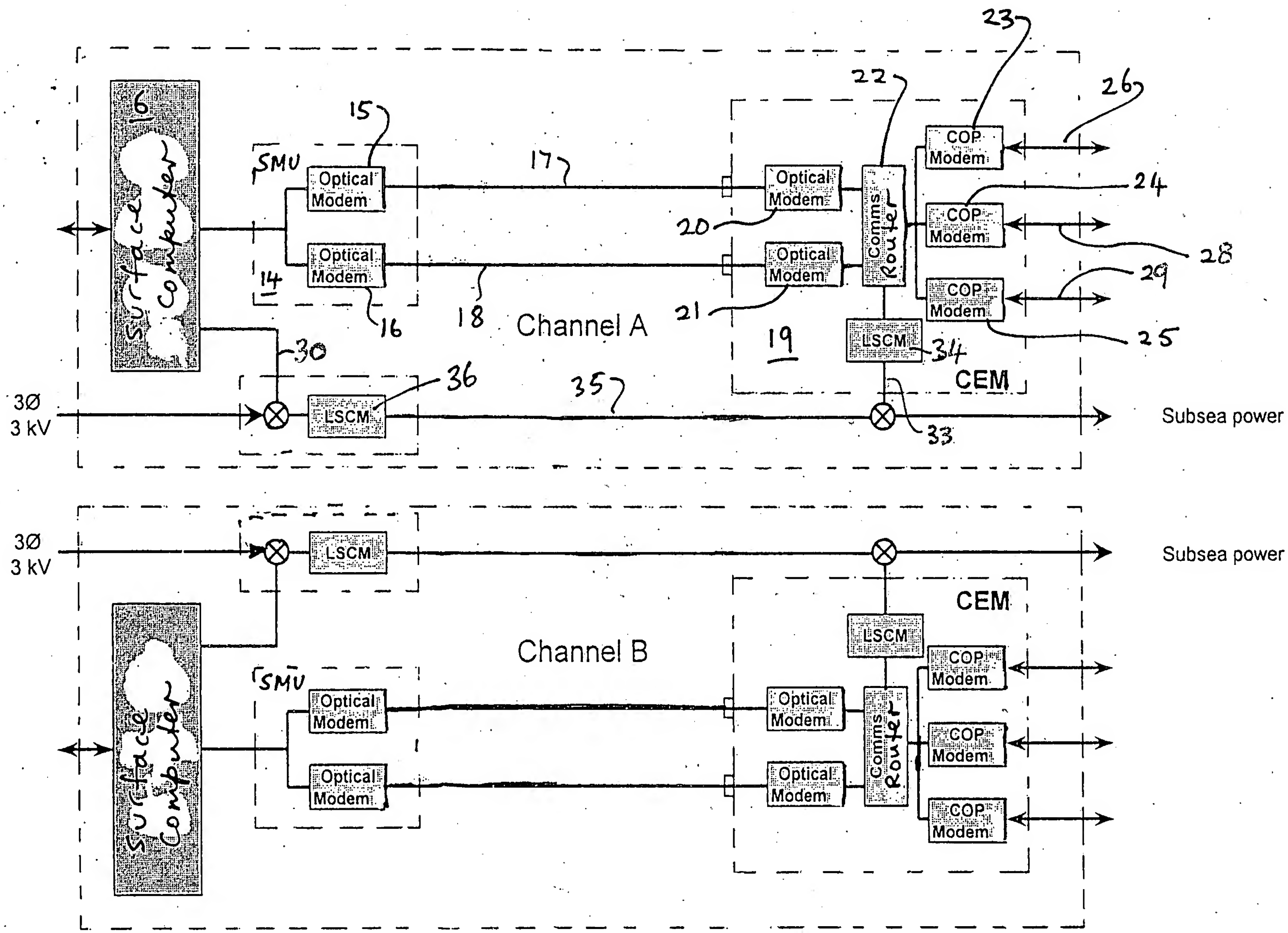

Surface Computer
6
SMU
14
Optical Modem
15
16
17
18
Channel A
Optical Modem
20
21
19
Comms Router
22
COP Modem
23
24
25
26
28
29
LSCM
34
CEM
30
36
35
33
3Ø
3 kV
Subsea power
Channel B


FIG. 4